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Deep Learning Metrics for Identifying Citrus Diseases and Disorders of Leaves and Twigs

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Under the supervision of

Dr. Kamlesh Lakhwani

Professor & Dy. HOD

Submitted by

Archna Goyal

(University Roll No.21PCON003)

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CERTIFICATE

This is to certify that the Research Plan entitled “Deep Learning Metrics for Identifying Citrus Diseases and Disorders of Leaves and Twigs**”** by Archna Goyal(University Roll No. 21PCON003) has been successfully submitted in fulfillment of the requirement for the Ph.D. in **Computer Science & Engineering** under the School of Engineering of **JECRC University, Jaipur,** during the academic year 2022-23.

The matter embodied in this Research Plan is original and has not been submitted to any other university to award any other degree.

Date: 27/5/2023

(Signature)	**(Signature)**	**(Signature)**
Chairman, DRC	**Member, DRC**	**Member, DRC**

Research Scholar's Basic Information

1. Name of the Candidate: Archna Goyal
2. Father's Name: Tara Chand Gupta
3. Mother's Name:Sarla Devi
4. Registration No.:21PCON003
5. Date of Birth: 05/11/1977
6. Permanent Address:H.No. 38, Shastri Nagar, Ajmer, District- Ajmer, Rajasthan, Pin Code- 305001
7. Address for Correspondence: H.No 887, Sector-28, Faridabad, District – Faridabad, Haryana, Pin Code- 121008
8. Email:goyalarchna511@gmail.com,archna.21pcon003@jecrcu.edu.in
9. Mobile No.: 7734018007, 7976401447
10. PG Degree Title: M.Tech (CSE) CGPA: 8.63
11. Title of Research Plan: Deep Learning Metrics for Identifying Citrus Diseases and Disorders of Leaves and Twigs

Date: 27/5/2023 Signature of the Candidate

Certificate.....*i*

Research Scholar's Basic Information.....*ii*

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CHAPTER 1

INTRODUCTION

A lot of things have a big effect on citrus yields, but diseases and pests are the two most important ones. There are many different diseases and pests that can hurt orange trees. Some of them look so much alike that it might be hard for farmers to tell them apart in time. The state of the art in computer vision has changed a lot in recent years thanks to the improvements in machine learning techniques. Because new network topologies have been made, researchers have been able to get very accurate results for picture classification, object detection, and semantic segmentation[1]. Because of this, several studies have used a model of machine learning to figure out what kind of sickness an image shows.Because it is such an important part of the agricultural economy as a whole, the citrus business takes steps to control diseases in citrus trees so that it doesn't lose as much money. The three diseases that are most dangerous to citrus trees are melanose, greasy spot, and scab. The citrus industry would gain from the creation of technologies that can find these diseases quickly and accurately. These technologies would make sure that the fruit is safe and of good quality, and they would also make the business more competitive and profitable. The goal of this study is to see if pattern classification methods can be used to find disease spots on citrus leaves. Scab, melanose, sticky patch, and normal leaf are the four ways to describe the different diseases that can affect a plant's leaves. To find out which way of putting diseases into groups works best, a comparison study was done with four different categories that were all made in-house. After the features were removed, they were put into groups using a supervised classification method called feature weighted Mahalanobis distance. This method was used to classify the features.

1.1 CITRUS DISEASES

Just like melanose, scab and greasy patch are dangerous diseases that can be found on a wide range of commercial types. The pathogen could cause the leaves to fall off, the fruit to be damaged or fall off early, the twigs to die back, and the tree to die. The sores on the leaves, stems, and fruit make it easy to find the pathogen. People think that scab, greasy spot, and melanose are some of the worst diseases that can happen to orange crops. There are many diseases that can affect the leaves of citrus trees, but these three are the most common and widespread. At the moment, there isn't a cure or way to avoid these diseases that could make them go away completely in places where they are already a problem, like southern Florida. At

the moment, the focus is on lowering the number of people who get sick with the disease and stopping any new cases from happening. The primary objective of this project is to investigate the efficacy of various classifiers in distinguishing normal leaves from those affected by scab, melanose, and sticky spot on the leaves, and to evaluate and contrast the results obtained by the two distinct classifiers. A study comparing the results of the two algorithms will also be part of the project. By using this technology, we can accurately identify these diseases, make sure that the fruit is safe and of good quality, and improve the citrus industry's ability to compete and make more money. During the last ten years, a number of researchers have tried to create tools for agriculture that use image processing and pattern recognition. Object shape matching functions, like the ones used by Woebbecke et al. (1995a) to build a vision system that can spot young weeds by their shapes. Some of these shape traits were roundness, aspect, perimeter, thickness, elongation, and different invariant central moments (ICM). Kataoka et al. (2001) made an automatic system for figuring out if apples are ready to be picked or not. It uses a color-based algorithm that is based on combining the Munsell and XYZ color systems. Burks (2000a) came up with a way to group different kinds of weeds by using color and texture traits as well as discriminant analysis. For this process, the color-co-occurrence method (also called the CCM method) was used to analyze images. This method could tell the difference between several different tree species, and it didn't matter how big the leaves were or which way they were facing. Both the Mahalanobis distance method and the neural network methods are often used to classify a wide range of things. But if the feature is distorted by noise, which happens when the distances are scaled, a single feature may have a value so high that it hides the information that the other features give, which leads to a wrong classification. To solve this problem, we use feature weighted Mahalanobis distance, which we do by putting the Mahalanobis Classifier into place.

1.3 CITRUS PRODUCTION

Agriculture has a lot of production risks, and in order to make decisions, a lot of different factors need to be taken into account. To successfully put management plans and growth programs into action, you need to know enough about the factors that have the biggest immediate effect on output. It's hard to understand how variables behave because their ties with each other are complicated and there are a lot of factors involved. Citrus production is hard because farms have a lot of differences in space and time. In citrus orchards, the amount of production is mostly based on the number and average size of the fruits. Both internal and external factors can have some effect on production in some way. Endogenous factors include

things like the genetic features of a species or variety and problems with the way the body works. The climate and crop conditions, especially the amount of watering and fertilizing, are the most important external factors (August, 2000, 2003). The output is also affected by how old the trees are and whether or not they reach a commercial production amount (more than 50 kilograms per tree) at an adult age (more than seven years after the transplant) (OrduzRodriguez et al., 2007). Citrus plants grow best at temperatures between 24 and 32 degrees Celsius, but they can also grow between 10 and 40 degrees Celsius. One of the many things that affect the size and shape of the fruit is the amount of carbs that are available to the growing flowers. When the temperature is between 22°C and 30°C, heating factors do not have much of an effect. But when the leaf's temperature goes above 32 degrees Celsius, the rate at which CO2 is taken in slows down. The effect of temperature on growth and competition between vegetative and sexual growth show some of the problems that come up when CO2 fixation is limited. Some of these problems are that the number of fruits set changes from season to season, the size of the fruits gets smaller, and the number of fruits set total goes down (August, 2003). The weather factors that have the most effect on the diameter of fruits at their equatorial point and the fresh dough used to make them are the highest and average temperatures, reference evapotranspiration, wind speed, and relative humidity. When it rains in the fall, the fruit gets bigger and has more juice. They also lower the amount of sugars and free acids in the fruit and help it grow in citrus fields in temperate places. Fruit can grow with between 900 and 1200 millimetres of rain or snow per year. On the other hand, even short periods of drought tend to make the fruit smaller. When the amount of water in the soil goes down or when it's dry, you need to water more. The size of the fruit is most affected by how much water it gets. But the effects of not drinking depend on the phonological state as well.

Fig.1.1 citrus disease leaf and fruit image

1.3 TAXONOMY OF CITRUS DISEASES

In agriculture, plant diseases are the main reason why production goes down, which in turn causes national economic loses. In many parts of the world, citrus foods are one of the best places to get vitamin C and other nutrients. On the other hand, citrus diseases had a big effect on both the number and quality of citrus fruits that were grown. There are many kinds of citrus tumours that can affect citrus plants like lemons, oranges, grapefruits, and limes. Anthracnose, greening, scab, and black spot are some of these problems. Here is a list of some diseases that can affect citrus, along with short descriptions of each.

1.4 CHARACTERISTICS OF SELECTED CITRUS DISEASES

Here is a thorough look at the technical details of a few citrus diseases.

1.4.1 Anthracnose

The anthracnose fungus is one of the first things to move into old or broken tissue. The plants grow on top of the dead copse that covers the area. The copse itself grows close to the plants because of rain spray, dew, and too much watering. Citrus can be recognised by its leaves, which have a big, smooth area in the middle, a rich brown colour, and a noticeable purple edge. Also, the fruit's symptoms usually get worse when other things like sunshine, chemicals with high temperatures, bug damage, and longer storage times are involved. In the example picture of anthracnose, the lesion spot is brown and has a diameter of 1.5 millimetres or more, which shows how old the fruit was when it got infected. The signs can be seen on the leaf and fruit of the citrus tree.

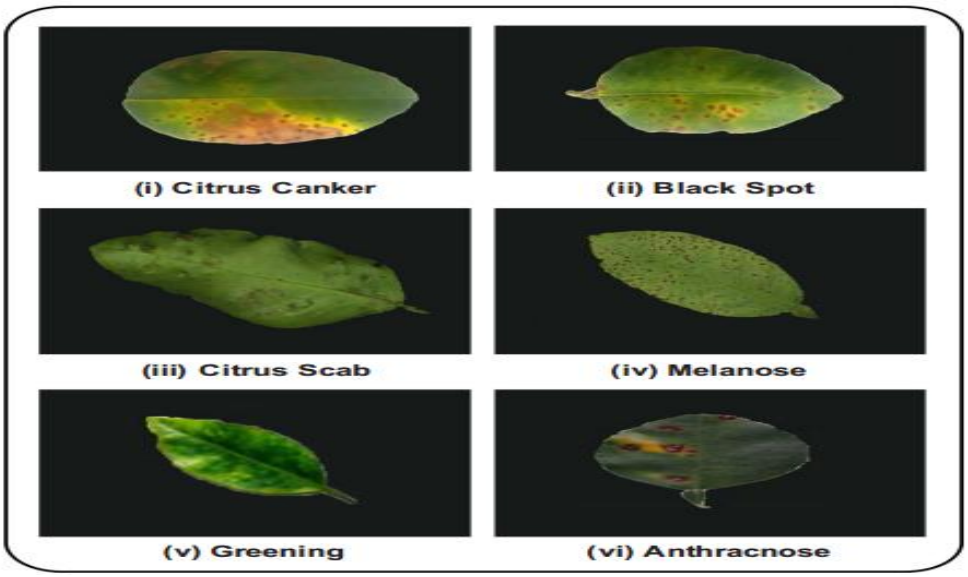


Fig 2 different types of citrus diseases

1.4.2. Black spot

The citrus black spot, which is often called CBS and often abbreviated as such, can happen when the plant is weak and the climate is good for the spread of disease. The symptoms of the citrus leaf and fruit are round, small, and found under grey and square areas that could be dangerous. The black spot tumour looks dark brown and is anywhere from 0.12 to 0.4 inches in diameter.

1.4.3. Canker

The orange canker spot is covered by wind-driven rain. The lesion can be anywhere from 2 to 10 millimetres wide and makes circles on the leaf of the orange fruit. On the other hand, the size of a tumour on a fruit can range from 1 to 10 millimetres, and each lesion is a different size. Most of the sores have a yellow ring around them that is wet with water. This growth is somewhere between dark brown and black in colour.

1.4.4. Scab

Acne scabies, which can be found on citrus leaves and fruits, are made up of a combination of fungal and microbial tissue. Acne lesions like these are barely elevated and range in colour from pink to light brown. Scab lesions have a coloration that is somewhere between yellow-brown and filthy grey.

1.4.5 Melanose

Melanose is a saprophyte, and the seriousness of the condition is determined by the number of inoculums that are on dead wood in the tree cover. This is because melanose feeds on dead biological matter. On the leaf, the first sign of the disease is a small brown spot that, over time, grows into a hole that is filled with a reddish-brown gum. On the other hand, the signs and symptoms of the fruit depend on

1.5 DATA SET

The dataset photos that are used for the extraction process are those that contain the feature extraction, which includes vectors, colour, texture, morphology, and the structure of holes (phenotypic nature). The colour of the fruits is an extremely important factor in the process of detecting, extracting, segmenting, and classifying them. The datasets were gathered from the competitions held on Kaggle.

1.6 CITRUS RESOURCES

India's citrus industry can take advantage of the country's importance as a source of important agro-horticultural traits that can be used to improve and grow the industry in India. During these studies, a number of citrus species, including a few new ones, were found and recorded.

Figure 1. Pictures of brown marmorated stink bug taken from different angles.

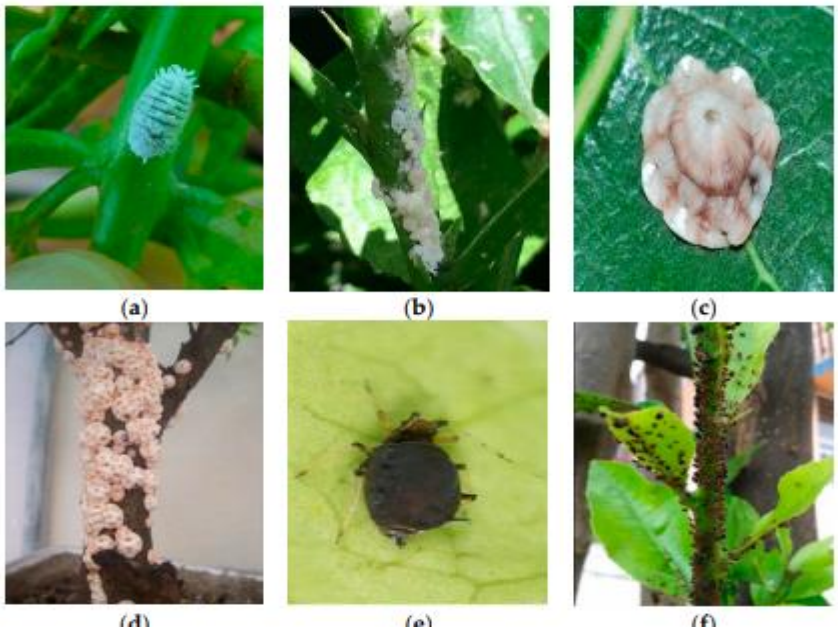


Figure 1.3. Representative images of citrus diseases. (a) citrus anthracnose, (b) citrus canker, (c) citrus melanose, (d) citrus scab, (e) sooty mold, (f) leaf miner, an

CHAPTER 2

LITERATURE REVIEW

Diseases can just as easily attack plants as they can mammals. Citrus is a big plant that is grown all over the world, but particularly in the tropical regions since it contains a high concentration of vitamin C and other significant nutrients. Citrus diseases have had a widespread impact on citrus output, which has resulted in a decline in the overall quality of the fruit and a loss of revenue for the growers. The identification and categorization of plant diseases has become more reliant in recent years on image processing and computer vision techniques. This trend began about ten years ago. The early discovery of infections in citrus plants is helpful in preventing the diseases from spreading across the orchards, which in turn serves to minimise the farmers' financial loss. Your viewing enjoyment is ensured by the presentation of the following image dataset, which features citrus fruits, leaves, and stems. The collection includes photographs of citrus fruits and leaves from plants that are healthy as well as from plants that have been infected with diseases such as black spot, canker, scab, greening, and melanose. The vast bulk of the photographs were taken during the month of December in orchards that are located in the Sargodha area of Pakistan. This occurred around the time of year when the fruit was getting close to becoming ripe, and this was also the period of year when citrus plants had the most infections. The dataset was gathered by the University of Gujrat and the Citrus Research Institute working together, and the Department of Computer Science at the University of Gujrat is responsible for its ongoing maintenance and upkeep. Citrus canker is a bacterial disease that attacks the leaves of citrus trees and is the primary cause of the damage that citrus orchards around the world are forced to contend with. Infections such as citrus canker have the potential to cause a great deal of damage. so it's important to have disease detection methods that are both quick and effective. In this study, we talk about a new way to find orange canker by taking pictures of leaves in the field, which is harder than taking pictures of leaves in a lab. This method uses world features and local features that are based on zones. In the first step of the process, an updated version of the AdaBoost algorithm is used on citrus tumours to figure out which of their features are most important for telling them apart from the background. Then, a canker lesion descriptor is made. This takes into account both the colour and the local texture of canker lesion zones, which is what plant psychopathologists suggest. A hierarchical detection system with two levels has been made so that canker lesions can be found. Third, we look at the

suggested method and see how it compares to other ways of doing things. The results of the test shows that the proposed strategy can classify things just as a human expert would.

2.1 CITRUS DISTRIBUTION AND ORIGIN OF VARIOUS CULTIVARS

It was previously thought that the major point of origin for citrus was in south and south-east Asia. Citrus originated in Southeast Asia's tropical and subtropical climates, and then it spread to other continents, according to Webber 1967 and Calabrese 1992, respectively. Tanaka (Tanaka 1977, Gmitter and Hu 1990, and Roose et al. 1995) produced a map of the region in South-East Asia that was most likely the birthplace of citrus species and their relatives. This region comprised sections of North East India, North Myanmar, Yunan, and the southern part of the Chinese island of Hainan. Tanaka's work was released in the books Tanaka 1977, Gmitter and Hu 1990, and Roose et al. 1995. In 1977, Tanaka's findings were written up in a book with the same name. Citrus crops, which have a nice colour, a sweet and refreshing taste, and other desired qualities, have grown in many countries around the world because they have long been traded internationally. Citrus crops stand out because of their bright colours, sweet and refreshing tastes, and other qualities that make them very valuable.

2.2 BENEFICIAL PROPERTIES OF CITRUS

Citrus species, such as C. sinensis, C. reticulata, C. limon, and C. paradisi, among others, play an important part in the development of humans' increasingly health-conscious modern lifestyles. These fruits are known for their high nutritional value. According to Liu et al. (2012), the promotion of citrus consumption is crucial for improving human health because of the high nutrient density of citrus fruits, the low-fat and low-sodium profiles of citrus fruits, and the connections between citrus fruit intake and the avoidance of chronic diseases. According to the USDA's National Nutrient Database (2011), orange juice has a folate content that is significantly greater than that of other regularly consumed fruit liquids. Folate can be found naturally in citrus fruits and juice.

2.3 MORPHOLOGICAL ANALYSIS OF CITRUS

The observable morphological trait is the foundational component for distinguishing between the several genotypes that comprise a single species. Morphological classification is still an important aspect of plant systematics despite the fact that it is both simple and inexpensive to differentiate, in addition to its informative character. Many taxonomists have used physical classifications of citrus, with Tanaka's (1967) and Swingle's (1972) being the most widely used. Morphological analysis is still taken into account and has been used as the first step in identifying cultivars and figuring out how diverse they are in a wide range of crops. Watermelon (Huh et al., 2008), sweet potato (Elameen et al., 2010), and agave (Rodriguez-

Garay et al., 2009) are some of these crops. Because of all the benefits, it would be in the north-eastern part of India's best interest to encourage the growth of many different kinds of fruit. For the best crop improvement and conservation measures, it will be helpful to have an exact evaluation of these citrus forms and a description of their shape. The citrus tristeza virus, sometimes known as CTV, and the procedures used to index it According to Ahlawat (1997), the Citrus Tide Virus, often known as CTV, is the virus that causes the most widespread and economically significant viral disease in the world. According to Moreno et al. (2008), the fact that most citrus species grown on their own roots were symptomless hosts for many citrus tristeza virus isolates and that the virus was only found in phloem cells showed that citrus tristeza virus probably first appeared many years ago in South East Asia and the Malayan archipelago, where citrus first grew, and then co-evolved with citrus hosts. Zaragoza (2007) says that it is unlikely that the orange tristeza virus would spread during that time. Citrus plants spread from where they first grew to other parts of the world 19 because citrus fruits and seeds were carried far and wide. (Moreno et al., 2008) say that the spread of the pathogen in many citrus-growing areas around the world is likely due to the fact that quarantine procedures for detecting pathogens were not good enough in the past, people didn't know what the symptoms were, and seeds were often replaced with living plants. The Citrus tristeza virus, which is also called Ctv, is the most complex and common member of the family Closteroviridae.

Muhammad Sharif et. al. In agriculture, plant diseases are the primary factor that contributes to a decrease in production, which in turn results in economic losses. Citrus fruits, such as oranges and lemons, are a significant source of nutrients for plants all over the world, including vitamin C. Citrus diseases, on the other hand, have a devastating impact on both the quantity and quality of citrus fruit. Since the beginning of this century, computer vision and image processing techniques have been put to extensive use in the process of identifying and categorising illnesses that affect plants. We suggest a hybrid method for the detection and categorization of illnesses in citrus trees in this study. The proposed procedure is broken down into two basic stages: (a) the identification of the lesion spot on the citrus fruits and leaves, and (b) the categorization of citrus illnesses. An upgraded input image is processed using an optimised weighted segmentation algorithm, and then the citrus lesion spots are recovered from the processed image. After that, a codebook is created that combines colour, texture, and geometric elements. A hybrid feature selection approach, which is comprised of the PCA score, entropy, and skewness-based covariance vector, is used to choose the best features as well. This method is used in conjunction with the PCA score. This method lets you choose the best features. This method is used to pick out the most attractive traits. A Multiclass Support Vector

Machine, or M-SVM, is used to classify citrus diseases based on the chosen traits. With the help of the Citrus Disease Image Gallery Dataset, the method that has been given has been tried out. This dataset is a mix of Plant Village, the Citrus Pictures Database of Infested with Scale, and our own database of collected photos. We were able to find and organise citrus diseases like anthracnose, black spot, canker, scab, greening, and melanose with the help of these resources. The new method works better than the old ones and has a classification accuracy of 97% on the citrus disease picture gallery dataset, 89% on the merged dataset, and 90.4% on our own local dataset.

Zahid Iqbal el.al. Fruits derived from citrus trees, which include lemons, mandarin oranges, oranges, tangerines, grapefruits, and limes, are widely cultivated in many parts of the world. The businesses that produce citrus produce a significant amount of trash each year, with approximately fifty percent of the fruit's peel being lost to a variety of plant ailments on an annual basis. In this study, we give an overview of the various methodologies that are relevant to the detection and categorization of diseases that affect the leaves of citrus plants. This article provides a comprehensive taxonomy of illnesses that affect citrus leafs. At the outset, a comprehensive discussion is had regarding the difficulties associated with each stage, which has an impact on the accuracy of the detection and classification processes. In this paper, there is also a full literature review of the different ways that automated disease detection and categorization can be done. In order to reach this goal, we study different ways to do picture preprocessing, segmentation, feature extraction, feature selection, and classification. In addition, you should also address the significance of the approaches of deep learning and the extraction of features. The poll provides a comprehensive discussion on the studies, discusses their benefits and drawbacks, and identifies areas that require additional investigation. The findings of the survey indicate that the use of automated detection and classification methods for illnesses that affect citrus plants is still in its infancy. As a result, new technologies are required to achieve complete automation of the detection and classification procedures.

Alham F. Aji et al. devised a method with a linear complexity process with the goal of reducing processing time in order to make it possible to use it in a mobile device for remote access to the concept as well. In the process of machine learning, six different types of features are first collected from an image of a palm leaf through the use of image processing. After that, the patterns are learned through the use of the Neural Network approach. The learning process resulted in the creation of a classification model that was accurate, on average, 88% of the time. Following that, a mathematical equation was constructed based on the classification model so that it could be applied in a mobile device [1].

ToranVerma et al. after performing pre-processing on the collected photos, separated the Texture, The colour and wavelet features of the spots and stains in the images of rice fields that have been cut up. Image features have been utilised in the development of a linear vector quantization neural network model for the purpose of diagnosing leaf blast and brown spot diseases. In compared to the utilisation of individual features by the neural network model, the recognition effectiveness of models containing hybrid features is significantly higher. According to these findings, the linear vector quantization neural network identification model for rice leaf blast and brown spot recognition sickness provides a superior presentation with statistical and signal properties that have been passed for training [12].

Feng Qin et al. After the lesion was segmented using these approaches, the numbers of texture, shape, and colour features were extracted. Alfalfa Leaf Diseases did this study. After the traits were chosen, three supervised learning methods were used to build illness classification models: the support vector machine, the Knearest neighbour approach, and the random forest method. An analysis was carried out to compare the recognition results produced by the models. The findings indicated that when the features were chosen, the ideal model was the support vector machine model that had been constructed with a few essential features that were kept apart from a large number of potential outcomes. The recognition accuracies of the training set for the support vector machine model are close to 97%, whereas the recognition accuracies of the testing set were 98% [4].

Xie, C.Q. et al Using the grey level co-occurrence matrix at five different effective wavelengths, eight lesion features, including mean, variance, homogeneity, contrast, dissimilarity, entropy, second moment, and correlation, were recovered. Included characteristics were the average, standard deviation, degree of similarity or dissimilarity, and entropy. During the evaluation phase, all spectral-information-based configurations of the models showed excellent performance, with overall classification accuracies from 97% to 100%. With classification accuracies of 71%, 70%, and 70%, respectively, dissimilarity, second moment, and entropy, three of the eight lesion features used in the extreme learning machine model, were deemed suitable for use in surgical planning. This research showed that hyperspectral imaging might be used as a non-invasive diagnostic method for early and late blight illnesses in tomato leaf tissue [15].

V.K. Tewari et al. done extraction for different features, including channels like R, G, and B, as well as normalised 'r' and normalised 'g', were investigated. The same procedure was followed for both operations. It was determined that a bare minimum of 65% accuracy was required, with an average accuracy of 75%. The R2 result (i.e. 0.958) indicated a straight linear

correlation between the observed and anticipated nitrogen percent values, proving that nitrogen content in plants can be accurately estimated using only colour images [13]. Multiple image features were used to develop and validate regression models for the plant nitrogen content. **Sachin Jagtap et al**. detailed the approaches that various organisations have taken in order to preprocess the data. After gathering the data for the issue 3056 of the International Journal of Chemical Studies, they employed software similar to that of Adobe Photoshop to remove the noisy background and to isolate the foreground leaf image so that it could be further processed. After that, the pictures are adjusted to look better and transformed to the HSV colour scheme. Then, after each image has been processed individually, all of the images are first turned to grayscale, and then they are binarized. In order to get to the bare bones of the images, a morphological thinning process is applied to them. The photographs then underwent an enlargement process based on morphology, after which the smallest elements were removed. The next step is to assign labels to each image's associated pixel component, and finally, to remove the photographs' noisy regions. Finally, all of the improved binarized images are subjected to a typical edge detection algorithm, and shape-related features are retrieved using the pre-processing as a guide [11].

Summary of the Research papers of Citrus disease detection and classification.

Reference	**Publication Year**	**Purpose**	**Image Acquisition Technique**	**Deep Learning Architecture**	**Training Method/*classification***	**Dataset**	**No of Images**	**Accuracy**
Muhammad Sharif[5]	2018	Citrus Diseases Classification	RGB image	Multiclass Support Vector Machine (M-SVM)	msvm	Citrus Diseases Image Gallery	670	***97%***
Kamal KC[6]	2019	Plant Disease	Volumetric CT	CNN	End-to-end	Plant Village	6359	***96.9***%
Hafiz Tayyab Rauf[7]	2019	Citrus Fruits	RGB	MultiClass Support Vector Machine (M-SVM)	MSVM	Mendeley data	759	Not defined
Jayme Garcia[8]	2019	Plant Disease	RGB	CNN	Augmentation techniques/ transfer learning	https://www.digipathos-rep.cnptia.embrapa.br/.	***500***	***95.08***%
Yande Liu[9]	2017	Citrus Greening	citrus leaves	LS-SVM	LS-SVM training	Unpublished dataset	62	Not defined

Deng Xiaoling[10]	2016	Citrus Huanglongbing (Hlb0	RGB	BPNN modeling	two-stage BPNN modeling	Plant Village	***500***	***92***
GeorginaStegmayer[11]	2012	Citrus Diseases	RGB	MLP	learning algorithm	Plant Village	212	***94***%
Delia Lorente[12]	2011	Citrus Fruit	Hyperspectral	MLP	supervised learning method	CoolSNAP ES, Photometrics	250	95.5

2.4 SCOPE OF RESEARCH

In recent years, digital image processing and its related technologies have been developed and used in image analysis such as computer and machine vision analysis, and these technologies have been applied in industries, medicine, and agriculture. As part of this research, the citrus disease analysis and detection proposed. The captured citrus disease images have been used for disease detection. Various types of image processing methods are developed, used and implemented in MATLAB, such as image enhancement, segmentation, and feature extraction, will be obtain the expected result. This research aims at providing detailed steps involved in the identification of citrus disease detection and their implementation procedures using algorithms.

CHAPTER 3

RATIONALE

(Noteworthy Contributions in the Field of Proposed Work)

Citrus is one of the important fruits grown in more than 50 countries of the subtropical and tropical regions. Different types of citrus plants, such as oranges, acid limes, and lemon, are cultivated in these regions, and these citrus plants can be affected by different types of diseases, like fungi, bacteria, and viruses. The bacterium-based disease i.e. citrus canker is considered as a severe and serious problem in the growth of citrus plants. Citrus canker symptoms appear as small lesions that are surrounded by an oily, water-soaked margin and form a yellow halo on the affected area of plants. The citrus canker disease mostly causes spots to appear on the leaves and discoloration of the fruit skin. Figure 4.1.shows citrus canker lesions on the lemon leaf.

Figure 3.1.Lesions as Light Yellow, Raised Eruptions on Leaves

Leaf symptoms - Citrus canker disease is an infection. Lesions on the leaf can range in size from 2 to 10 millimetres in diameter and cause the leaf to grow concentric circles. They have a yellow ring around them and are surrounded by a wet edge. When the damage is new, the tumours may go all the way through the leaf and follow the shape of the damage instead of

being round. Lesions can also be shaped strangely. Figure 3.2 shows that as a lesion gets bigger, a fungus may grow in the middle of it, making it look like a bullet hole.

Figure 3.2 Citrus Canker Lesions on Fruit

Various types of citrus plants are cultivated all over India. India grows citrus on land that is the same size as 10.77 million hectares. Each year, the country makes 111.47 million tonnes of citrus. Table 4.1 shows how much orange fruit is grown in each of the south Indian states. The most limes, lemons, sweet oranges, and mandarins come from the states of Maharashtra, Andhra Pradesh, Karnataka, the North-Eastern States, Punjab, and Orissa. Madhya Pradesh also grows a lot of these fruits. Most of the land space in these groups is used to grow these fruits.

3.2 DISEASES DETECTION AND ANALYZING PROCESS.

3.2.1 Digital Image Processing: is a powerful tool that can be used to test a wide range of characteristics in many different areas and uses of agriculture. Digital image processing opens

up new ways to look at the results of agricultural studies, which can be used to improve how they are judged. [20]. In agriculture, digital image processing and their related techniques can be used for various purposes such as leaf surface measurement, structural changes, measuring diseased plant parts, recognition of phytopathogenic fungi and measuring pests and pesticides damages. Image processing can be used for the identification of various fungi and bacterium based diseases with different types of techniques and algorithms, which are used in agriculture domain for the following purposes: (a) disease detection of leaf, stem, and fruit, (b) shape identification of the affected area, (c) color determination of the affected area, (d) fruits size and shape determination.

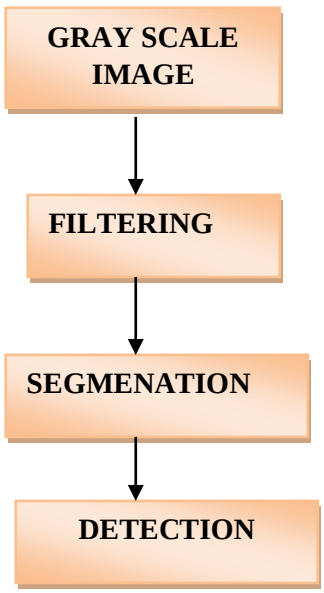


Fig. 3.2 Diseases Detection and Analyzing Process

3.2.2 Importance of Image Enhancement: Image quality is an important factor for analysis process of all image processing applications. In image processing, the accuracy of the output result depends on the quality of the image. Image quality is defined by a number of factors. Some of the essential factors are: (a) contrast, (b) brightness, (c) spatial resolution, (d) noise. In image processing, an 90 image is used to provide information to the viewer. For example, a forensic image supposed to provide accurate details to assist forensic investigations. In biological research, a plant's leaf picture is utilised to reveal the severity of the disease affecting the plant. Similar to this, a medical image is intended to give information about specific body components to aid in decision-making. For that, it is frequently important to extract several features from an image or the things that are visible in the image. Often the quality of the acquired image is not satisfactory due to factors, such as blur, low brightness, and noise. These types of images are necessarily to be pre-processed for removing irrelevant information or noise. This type of process is called image

enhancement. Image enhancement techniques are used to improve the quality of the image [3]. Digital image processing and their related technologies use digital images and help to increase or enhance the image quality, sharpness, and to extract the features of the image for analyzing the problem. Digital image processing considers the digital images are an input of the computer, and these images are manipulated by computer programs and algorithms, and then the results of the output images or objects are stored or displayed. These digital image output results can be displayed or stored for further process [69]. Analysis, identification, and detection of the citrus canker disease depend heavily on digital image processing and related technology. Images of the canker leaf, which are in digital form and used with the aid of digital image processing, are collected from the digital camera for the purpose of detecting citrus canker disease. In digital image processing, two crucial fundamental operations are picture augmentation and information extraction. The leaf is more visible and clear thanks to image enhancement techniques. This chapter discusses the value of image enhancement in identifying citrus canker disease.

3.2.3 Agriculture Domain Color Image Enhancement: Color image enhancement is an effective system that was used in agriculture domain to reduce the effects of noise, blurring and distortion of the agricultural image, improving the quality of the images. The color image enhancement filtering techniques are classified as the linear filters and non-linear filters, such as wiener filtering and median filtering. Both filtering techniques are used to reduce the noises, such as Gaussian, salt and pepper in the agricultural images, to get the results. In agriculture domain, image enhancement is done by two categories: (a) linear filtering which includes Wiener filters and its histogram processing, (b) non-linear filtering which uses median filters and its histogram processing.

3.2.4 Image Segmentation and Clustering: Image segmentation is often a necessary and important step in many other image processing tasks, such as image analysis, representing objects, visualising, and many others. For perfect picture segmentation, digital image processing takes into account the image's quality. There is a number of techniques [2] used to identify the plant diseases in their early stages. The traditional methods of plant disease detection are non-effective and time consuming for the large area of crops. When image processing techniques are used in the plant disease detection, they produce effective, accurate results. Different classification techniques [33] can be used for plant leaf disease detection, based on its different morphological features. Classifications of plant leaf diseases are used in many different fields, such as agriculture, biological study, and others, and the like. Lots of algorithms have been developed and implemented by researchers for detecting plant diseases.

3.2.5 Document Image Segmentation Using Region-Based Methods: Document Image Segmentation [18] is a process which was used to subdivide a document into its constituent

regions or objects, on the basis of the region-based method. The document image subdivision is carried out based on the depth of the problem being solved, and the region-based segmentation is used to partition the document image into a number of homogenous areas. The goal of this segmentation is to break up an image of a document into a few separate parts. Finding the boundaries between these regions based on discontinuities in gray levels. Document image segmentation can be used in many applications, which can Image Capturing Image Pre-processing Image Segmentation Shape Extraction Classification Disease Identification 63 identify the regions of interest in an image. Document image segmentation is one of the most challenging problems, addressed by the region based segmentation. In document image segmentation, region-based segmentation is used to segment the document images, and its performance is tested using a number of document images. The results show that the process of "segmenting" a picture of a document can never be 100% accurate because there is always a missing or extra region, and the only way to get accurate segmentation results is to either delete the extra region or mix it with the other regions.

3.2.6 Median Filter: The median filter is a nonlinear digital filtering method that is often used in digital image processing because it keeps lines while, under certain conditions, getting rid of noise. The median filter is used to have the higher end in conserving, removing noise images. The median of the image m is a group of pixel values and in this group 50% of the pixel values is less than median value m and half of the pixel values are greater than median value m. The median value, or the value of the pixel that lies in the centre of the distribution, is calculated using the neighbourhood's sorted value distribution. The values that are located in the vicinity of each individual pixel element are sorted using the median operator. This reduces the amount of visual detail lost as a result of edge blurring and blurring of the image.

3.3 COLOR IMAGE PROCESSING: For colour image processing, a colour digital picture is used. Each pixel in this picture contains information about colour. In a colour image, each pixel has three different numbers that measure how bright and what colour the light is. For storing a colour picture, memory is set up in a two-dimensional array. This group holds data about how bright each spectral band is.The quality of a chromatic light source can be described by one of three basic things: (a) the total amount of energy that flows from the light source, which is called Radiance; (b) the amount of energy an observer sees from the light source, which is measured in lumens, which is called Luminance; or (c) Brightness, which is a subjective term that includes the intensity of light.

3.3.1 Color Models: Color models provide a standard way to facilitate the specification of colors by defining a 3D coordinate system, and colors in color model can be specified by a

single point. These different types of color models can be used in the applications according to the requirement of the process. Color models most commonly used in image processing are:

(a) RGB (Red, Green, Blue) model used in color monitors and video cameras,

(b) CMY (Cyan, Magenta, Yellow) and CMYK (CMY+Black) model used in color printing,

(c) HSI (Hue, Saturation, and Intensity) model

used for human description and interpretation of colors. The CMY colour model is the one that is used in the business that publishes colour pictures. The RGB colour model is used in computer graphics and image processing tools, as well as colour CRT monitors. Image processing system manipulates hue, saturation, and intensity separately, when it uses the HSI color model

3.3.2 HSI Color Model: HSI color model represents various colors with three basic components: hue (H), saturation (S), intensity (I). Various types of colors can be obtained with adjusting the values of hue, saturation, and intensity. Figure 3.9. illustrates the HSI color space representation. In HSI color model, the hue component is used to describe the various colors using angles. For example, the degrees 0, 120 and 240 represent the primary. The brightness shows how much the colour is diluted by white. On the strength scale, 0 means completely black and 1 means completely white. Various types of color models are used in image processing such as RGB, CMY, CMYK and HIS. But, the RGB color model is mostly used in various types of applications because its device- dependency. It can be used in image analysis, color image segmentation, and so on.

3.4 RGB IMAGE SEGMENTATION In the proposed study, patch- and label-based segmentation is used. This method looks at the values of the pixels in a certain area, groups them together based on the joining, and makes a shorter list of the results. In this way of segmentation, colour mapping and clustering are used. The picture of the damaged plant leaf is mapped and patched based on the colours, and then the parts of the image are named using clustering. Also, the areas that are divided are separated by cutting out other areas that are labelled.

3.4.1Grayscale Image Representation In image analysis, the grayscale model is a common paradigm. Its visuals are expressed by intensity values, which can be any shade of grey you can think of, from completely dark to completely light. The value of a pixel's intensity is represented by a range that goes from 0 to 1 (the minimum and highest values) and from 0 to 255 (the range of grey shades). The lowest number for a pixel's intensity is 0 and the highest is 1. The lowest number is 0, and the highest is 1. Image pixel data is saved using quantization and binary representations. There is only one way to describe a grayscale image using a matrix.

3.5 IMAGE COLLECTION OF CITRUS DISEASES

When compared to citrus pests, citrus diseases have more consistent characteristics. The majority of the photographs depicting citrus infections were taken in the summer, right after a significant rainfall, as this was when the condition was most prevalent. In order to capture more information, the camera was placed in close proximity to the illnesses. At a later stage, certain diseases will cause holes to appear in the leaves. To make it easier to make a comparison, pictures of the holes that were chewed out of the leaves by pests (PH) were put on the label for the disease. The visuals shown in Figure 3 are representative of each disease.

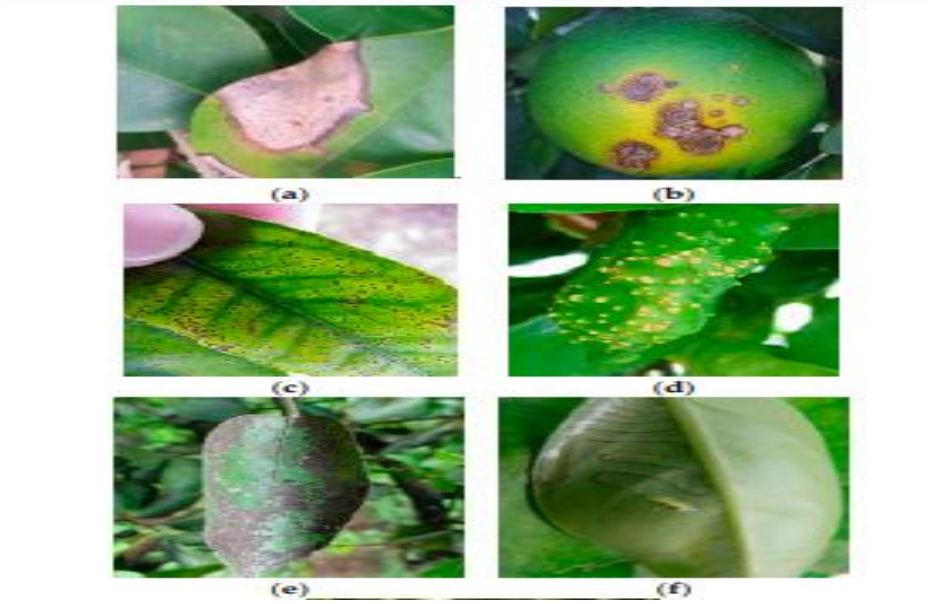
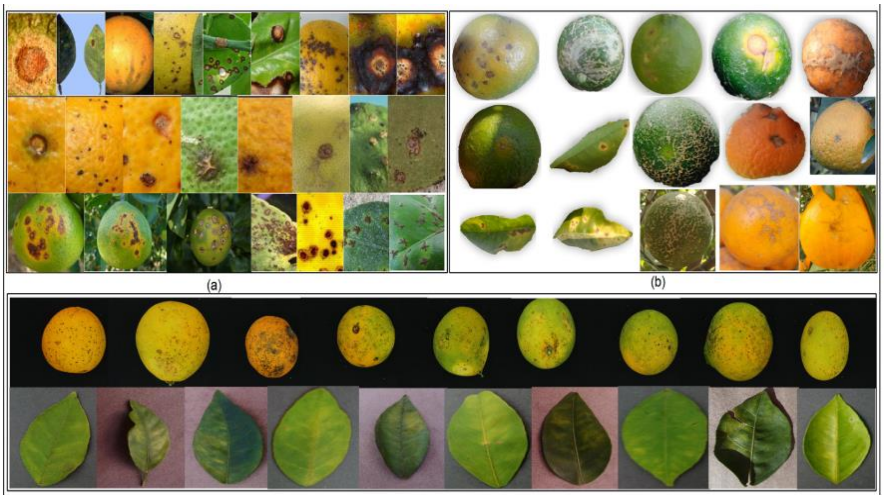


Fig 3.3 Sample images of selected diseases



. Fig 3.4 Citrus Diseases Image Gallery Dataset

Chapter 4

OBJECTIVE OF THE RESEARCH

The main objectives of the proposed research work are listed below

- To study the existing research on citrus disease detection and classification using deep learning.
- To collect a dataset that consists of the information about citrus disease and analyzes various types of citrus disease.
- To develop and implement the algorithm for segmentation Feature extraction and classifiers in detection and classification of citrus plants leaves diseases.
- To design, implement and measure the performance in terms of accuracy and precision of implemented model for detection and classification of citrus diseases.

Process

1. Collect benchmark datasets (this dataset must contain images of citrus plants leaves diseases images authentic source of data).
    - Pre-processing - resize and RGB conversion
    - Segmentation - region of interest and binary conversion based region will be segmented
    - Feature extraction- segmented area features will be extracted
    - For training and testing, VGG16, InceptionV3, MobileNetv2, ResNet50, GoogleNet, DenseNetwill be used for the detection and classification Training methods of SGDM, ADAM, Root Mean Square Propagation
2. Divide data into training and testing samples
3. Train standard CNN models with the training data set which may/may not be labelled (knowing inputs and targets) mathematically given by:
   $(\boldsymbol{X^1},\boldsymbol{Y^1})$……$(\boldsymbol{X^M},\boldsymbol{Y^M})$
   The weights are to be learnt in this phase.
4. Test the models and compute evaluation parameters which can be: Sensitivity, Accuracy, Recall, Precision, F-measure, specificity and any other parameter(s) if required.
5. Compare the performance of different CNN models listed above (and other deep learning models).

CHAPTER 5

RESEARCH METHOD

In agriculture, plant diseases play a significant role in reducing crop production and causing economic losses. Citrus fruits, such as oranges and lemons, are a vital source of nutrients worldwide, including essential vitamins like vitamin C. Orange diseases, on the other hand, hurt not only how many oranges are grown but also how good they taste. In recent years, computer vision and picture processing technologies have helped a lot with identifying and classifying plant diseases, especially those that can spread from citrus trees to other types of plants.

The suggested system uses a combination of different research methods to find and classify citrus diseases. The process has two main steps: finding broken spots on citrus fruits and leaves and putting different kinds of citrus diseases into different groups.

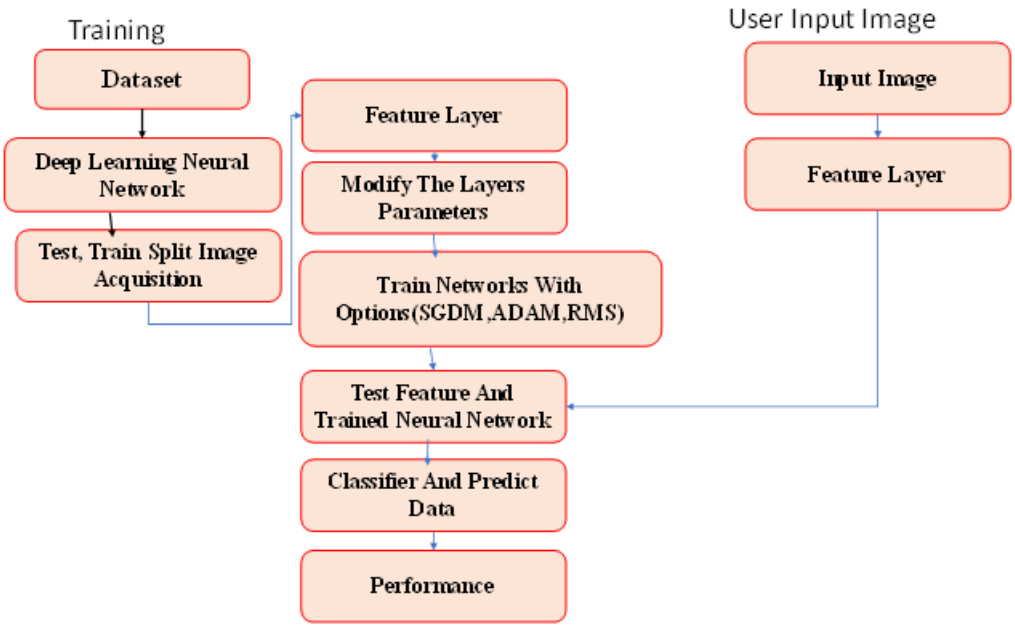


Fig 4.1 Proposed Flow Chart for Classification of Citrus Disease

In the first stage, the system focuses on detecting lesion spots on citrus fruits and leaves. This involves developing an algorithm that utilizes computer vision techniques to locate and isolate areas of interest corresponding to the lesions. Image segmentation methods, such as thresholding, edge detection, or clustering, applied to identify the lesion spots accurately.

In the second stage, the system performs classification of citrus diseases based on the identified lesion spots. Deep learning models, Deep learning models (CNNs) employed to analyze the lesion spot images and classify them into different disease categories. The Deep learning

models will be trained on a dataset consisting of labelled images of healthy citrus leaves and leaves affected by various diseases.

The proposed system aims to provide an automated and efficient solution for citrus disease detection and classification. By accurately identifying and categorizing citrus diseases, farmers and agricultural experts can take timely preventive measures, such as targeted treatments or crop management strategies, to mitigate the spread and impact of these diseases. Ultimately, this system contributes to maintaining and improving citrus fruit production and minimizing economic losses in the agricultural industry.

5.2 MODULES

Image processing, image segmentation, feature extraction, and classification of citrus diseases using deep learning are some of the major components of the suggested method. texture features, feature selection, and classification. Here's a breakdown of each component:

- Image processing
- Image segmentation
- Feature extraction
- Texture features
- Feature selection
- Classification

Image processing: This step involves preprocessing the citrus leaf images to enhance their quality and remove any noise or artifacts. Image processing techniques such as resizing, normalization, and denoising may be applied to ensure uniformity and improve the accuracy of subsequent steps.

Image segmentation: Image segmentation techniques are used to separate the citrus leaf images into distinct regions or objects of interest. In the context of citrus disease detection, segmentation can help isolate and highlight the affected areas or lesions on the leaves, making them easier to analyze and classify.

Feature extraction: After segmenting the citrus leaf images, relevant features need to be extracted to characterize the disease patterns. Various techniques can be employed, such as extracting color-based features (e.g., color histograms), shape-based features (e.g., geometric measurements), or texture-based features (e.g., texture descriptors).

Texture features: Texture features play a crucial role in capturing the unique patterns and textures associated with different citrus diseases. Techniques such as Local Binary Patterns

(LBP), Gray Level Co-occurrence Matrix (GLCM), or Gabor filters can be used to extract texture features that describe the spatial arrangement and distribution of pixel intensities.

Feature selection: In order to reduce dimensionality and improve classification performance, feature selection methods can be applied to identify the most informative and discriminative features. These methods aim to retain the most relevant features while discarding redundant or irrelevant ones, thereby improving the efficiency and accuracy of the classification process.

Classification: Once the features have been extracted and selected, a classification algorithm is applied to assign the citrus leaf images to specific disease categories. Deep learning models will be used for image classification tasks due to their ability to learn hierarchical representations and capture complex patterns within the data.

CHAPTER 6

JUSTIFICATION FOR SELECTION OF RESEARCH AREA

The prediction of citrus diseases holds significant importance for several reasons:

Early detection and prevention: By accurately predicting citrus diseases, farmers and agricultural experts can detect potential outbreaks at an early stage. Early detection allows for timely and targeted interventions, such as disease management strategies, use of appropriate fungicides, or implementation of cultural practices, to prevent the spread of diseases and minimize their impact on citrus crops. This proactive approach can save valuable time and resources by mitigating the damage before it becomes severe.

Crop management and yield optimization: Citrus diseases can significantly impact the yield and quality of citrus crops. Predicting diseases enables farmers to make informed decisions regarding crop management practices, resource allocation, and optimization of yield. By identifying high-risk areas or susceptible varieties in advance, farmers can implement preventive measures, such as selective spraying, crop rotation, or use of disease-resistant cultivars, to protect their crops and maximize productivity.

Economic impact: Citrus diseases can result in substantial economic losses for farmers and the agricultural industry as a whole. By accurately predicting diseases, stakeholders can take proactive steps to minimize financial losses. Timely intervention and disease management strategies can help preserve the market value of citrus crops, maintain consistent supply, and reduce the need for expensive remedial actions or replanting.

Sustainable agriculture and reduced chemical use: Effective disease prediction contributes to sustainable agriculture practices by minimizing the reliance on chemical inputs, such as fungicides. By accurately predicting diseases, farmers can adopt integrated pest management (IPM) strategies that emphasize preventive measures, cultural practices, and biological controls. This approach reduces the use of synthetic chemicals, minimizes environmental impact, and promotes a more ecologically balanced farming system.

Scientific research and knowledge advancement: Disease prediction in citrus plants contributes to the broader field of plant pathology and agricultural research. By studying disease patterns, understanding disease dynamics, and developing accurate prediction models, researchers can gain insights into the underlying factors that contribute to disease outbreaks. This knowledge can inform future research, improve disease management strategies, and lead to the development of more targeted and effective solutions.

CHAPTER 7

EXPECTED OUTCOME OF THE PROPOSED WORK

The suggested method includes several different steps: image capture, categorization, feature selection, feature extraction, and picture segmentation. Almost all ailments may now be classified accurately thanks to disease diagnosis technologies. The segmentation of the citrus disease picture was by far the hardest and most difficult part. It was split into two parts: first, the background piece had to be found and taken out, and then the diseased area had to be separated.

Following are the expected outcomes or main strength of our work.

- Increase the accuracy of disease detection better than the exiting model
- • The Clustering Based Segmentation technique should be used for background segmentation since it produces very robust results when compared to occlusion of leaves, illumination, and other comparable variances.
- It will classify the detected infected area on leaf and fruits.
- Remove noise that will create false detection of citrus diseases.
- Proposed study will reduce the complexityanderror rate of the system.
- The speed of the system is expected to be increase as the complexity of the system will be reduced.

Why Reduce the amount of time people have to work and the chance that they will make a mistake. This will help end users (farmers) spray the least amount of fertilisers and chemicals possible, which helps protect the environment.

- In order to evaluate the proposed approach for citrus diseases detection by measuring the parameters such as Precision, Sensitivity, Specificity and Accuracy.

WORK PLAN/TIME LINES

Sampleresearchplanof minimumtime line

Researchactivity	6	12	18	24	30	36	*
Coursework							
Literaturesurvey							
Methodologyreports							
Quarterlyreports							
Communicationofpapers							
Preparationoffinalthesis							
Submissionofthesis							

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